Figures

	Hash-based approach (2-way-set-associative) Fig. 1	CAM-based approach Fig. 2	H-CAM-based approach (2-way-set-associative) Fig. 8
ASIC output pins	21	128	128
ASIC input pins	160	32	32
RAM size (est. cost)	2M x 160 ($800)	1M x 32 ($80)	1M x 32 ($80)
CAM size (est. cost)	-	1M x 128 ($3200)	100K x 128 ($320)
Hash Pointer RAM size (est. cost)	-	-	2M x 20 ($100)
Search Data RAM size (est. cost)	-	-	1M x 128 ($320)
Database size (entries) supported	Depends	1M	Depends
Associate content RAM read	2 reads per search	1 read per search	1 read per search
Estimated cost	$800	$3280	$820
Estimated Power consumption	20W	162W	28.5W

Table 1

	Search value (6-digit wide)	Hash 1 output (4-digit wide)	Hash 2 output (2-digit wide)	CAM 1 content	CAM 2 content	Memory content
1	-	-	-	-	-	-
2	324238	7783	63	-	-	-
3	-	-	-	-	-	63: 324238,17
4	578901	6311	63	-	-	63: 324238,17
5	-	-	-	-	100:6311	63: 324238,17 100: 578901,23
6	322413	6311	63	-	100:6311	63: 324238,17 100: 578901,23
7	-	-	-	200:322413	100:6311	63: 324238,17 100: 578901,23 200: - , 86
8	578901	6311	63	200:322413	100:6311	63: 324238,17 100: 578901,23 200: - , 86
9	322413	6311	63	200:322413	100:6311	63: 324238,17 100: 578901,23 200: - , 86
10	324238	7783	63	200:322413	100:6311	63: 324238,17 100: 578901,23 200: - , 86

Table 2

Memory Size and Bandwidth requirement		Old method (Fig. 1)	H-CAM (Fig. 11)
Memory size	Search Data memory	8 million entries	1 million entries
	Hash Pointer memory	none	2M pointers
	Total (Mbit)	1024	164
Memory bandwidth	Reads/search	8	2 per H-CAM

Table 3

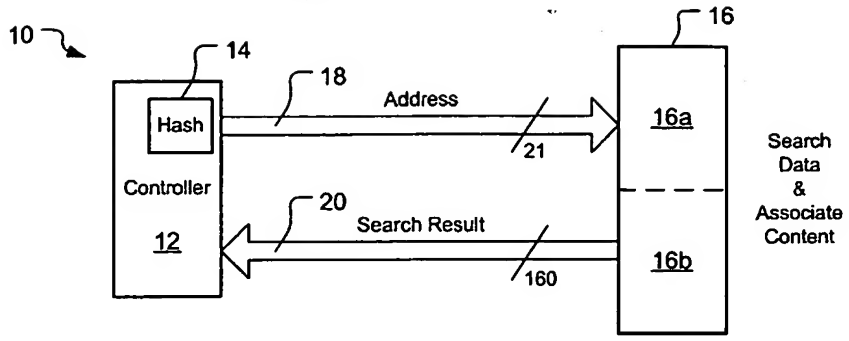


FIG. 1 (background art)

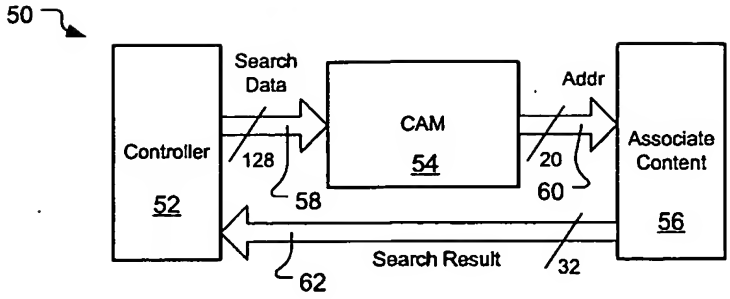


FIG. 2 (background art)

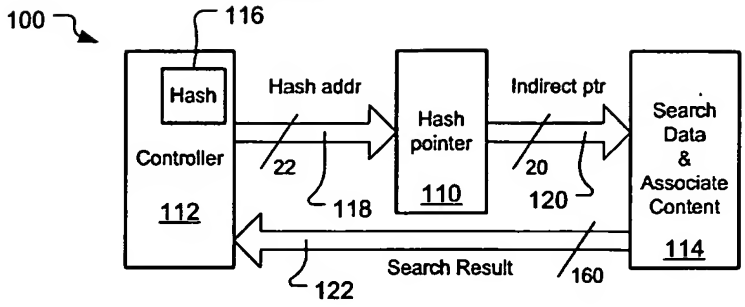

100
116
Hash
Controller
112
Hash addr
22
118
Hash
pointer
110
Indirect ptr
20
120
Search
Data
&
Associate
Content
114
Search Result
122
160

FIG. 3

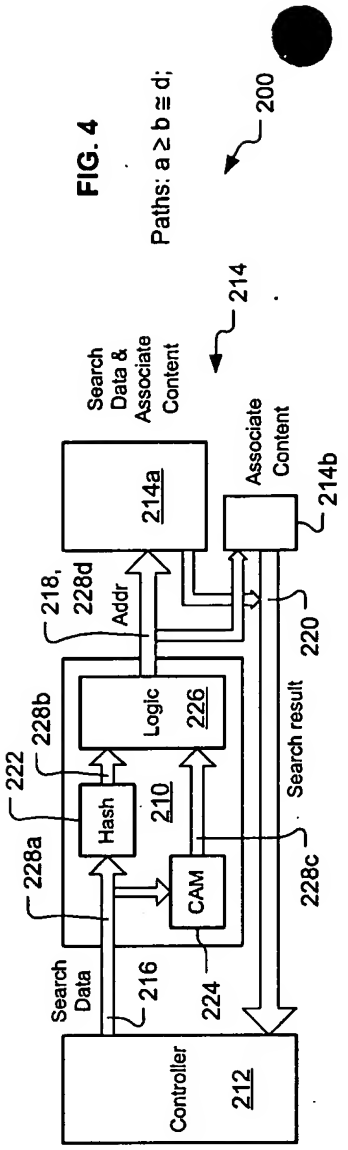


FIG. 4
Paths: a ≥ b ≡ d;
200
214
Search Data & Associate Content
214a
Associate Content
214b
218, 228d
Addr
220
Search result
228b
222
Logic
226
Hash
210
228a
CAM
228c
Search Data
216
224
Controller
212

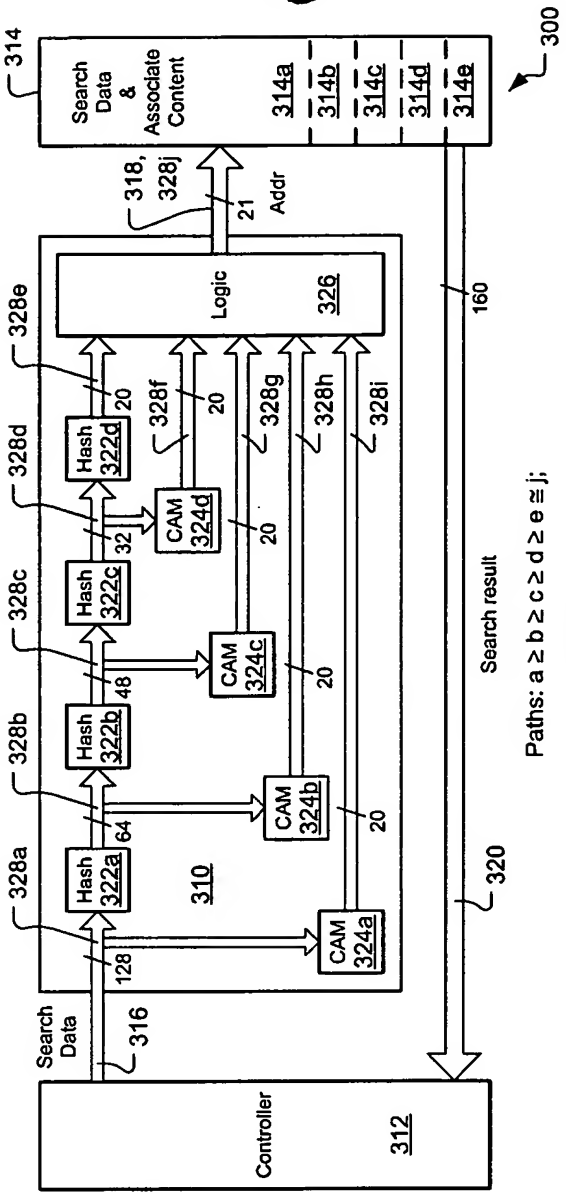
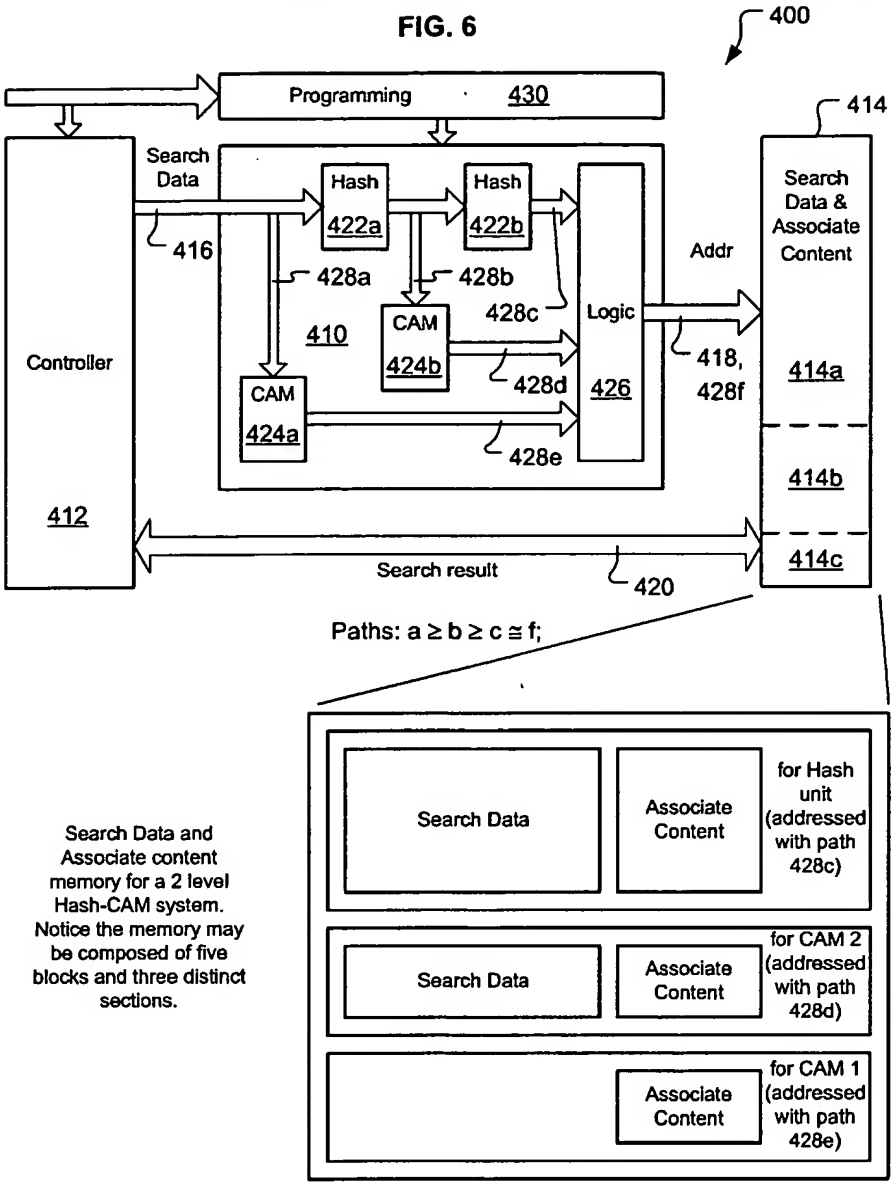

314
Search Data & Associate Content
314a
314b
314c
314d
314e
300
318, 328j
21
Addr
328e
Logic
326
160
328d
Hash 322d
20
328f
20
328g
328h
328i
328c
Hash 322c
32
CAM 324d
20
328b
Hash 322b
48
CAM 324c
20
328a
Hash 322a
64
CAM 324b
20
310
128
CAM 324a
320
Search result
Paths: a ≥ b ≥ c ≥ d ≥ e ≥ j;
Search Data
316
Controller
312

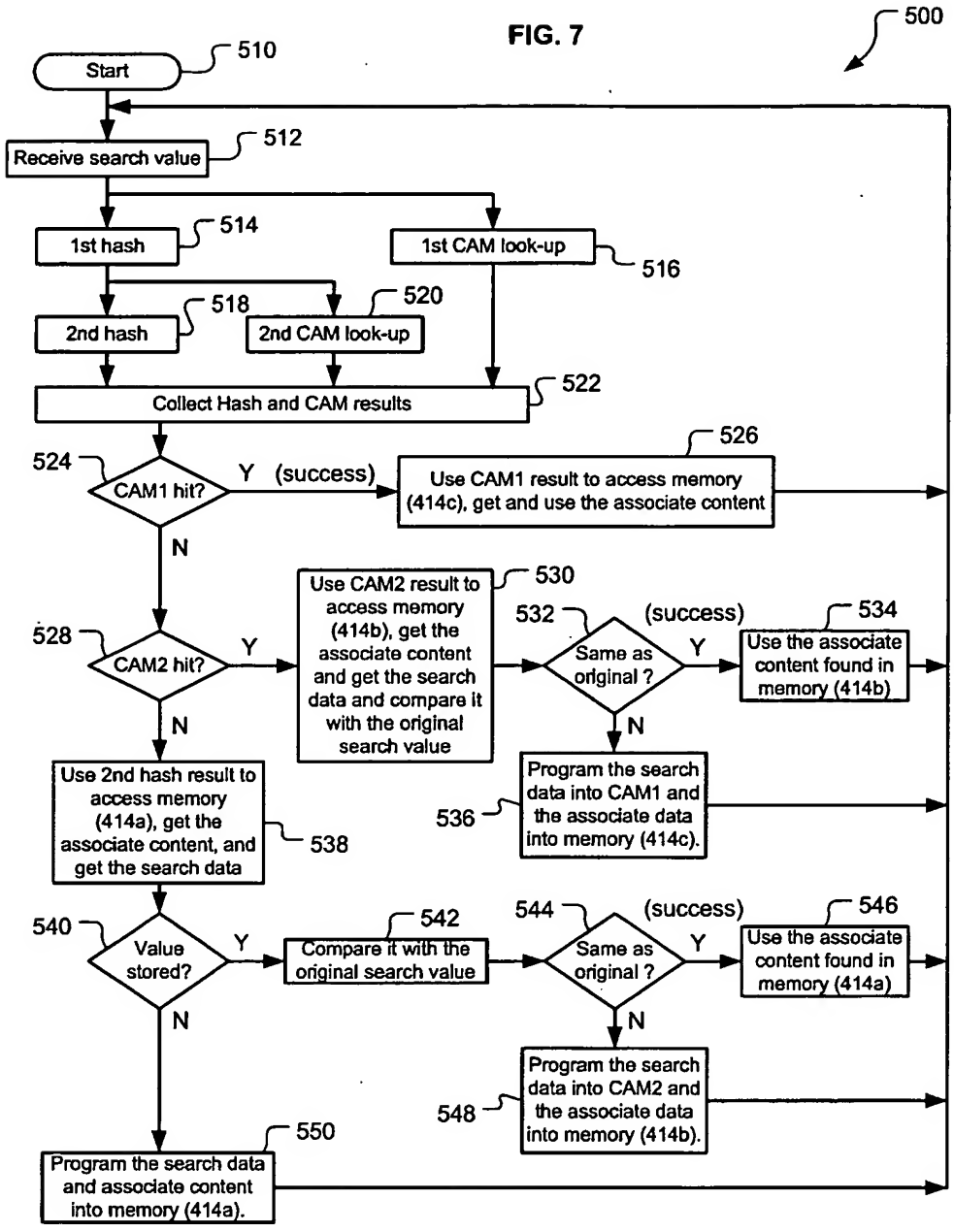
FIG. 5

FIG. 6



Search Data and Associate content memory for a 2 level Hash-CAM system. Notice the memory may be composed of five blocks and three distinct sections.

FIG. 7


500
Start
510
Receive search value
512
1st hash
514
1st CAM look-up
516
2nd hash
518
2nd CAM look-up
520
Collect Hash and CAM results
522
CAM1 hit?
524
Y (success)
Use CAM1 result to access memory (414c), get and use the associate content
526
N
CAM2 hit?
528
Y
Use CAM2 result to access memory (414b), get the associate content and get the search data and compare it with the original search value
530
Same as original ?
532
(success)
Y
Use the associate content found in memory (414b)
534
N
Program the search data into CAM1 and the associate data into memory (414c).
536
Use 2nd hash result to access memory (414a), get the associate content, and get the search data
538
Value stored?
540
Y
Compare it with the original search value
542
Same as original ?
544
(success)
Y
Use the associate content found in memory (414a)
546
N
Program the search data into CAM2 and the associate data into memory (414b).
548
Program the search data and associate content into memory (414a).
550

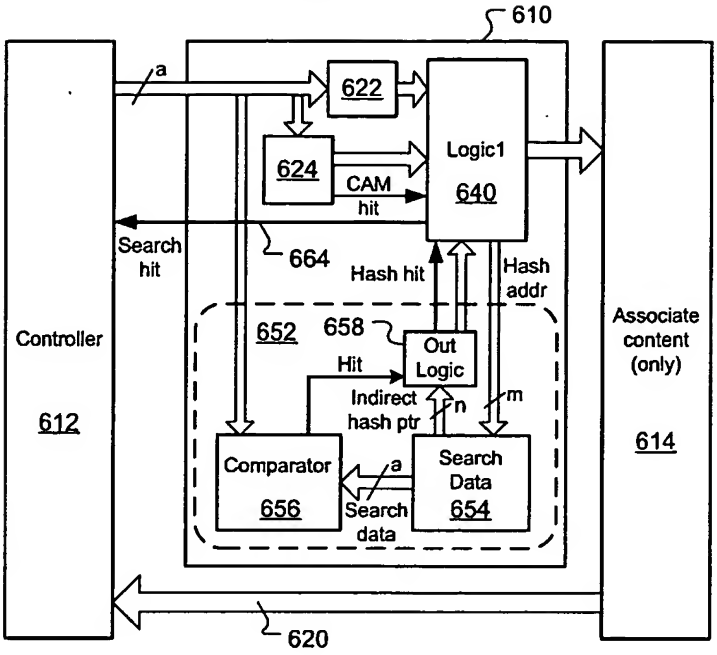

610
600
a
622
624
Logic1
640
CAM
hit
Search
hit
664
Hash hit
Hash
addr
Controller
612
652
658
Out
Logic
Hit
Indirect
hash ptr
n
m
Comparator
656
a
Search
data
Search
Data
654
Associate
content
(only)
614
620

FIG. 8

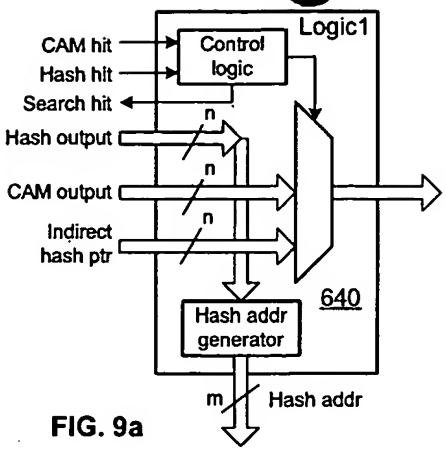
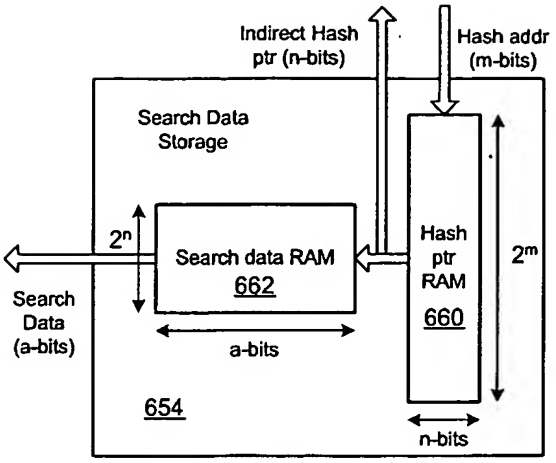

Logic1
CAM hit
Hash hit
Search hit
Control logic
Hash output
n
CAM output
n
Indirect hash ptr
n
640
Hash addr generator
m
Hash addr

FIG. 9a

FIG. 9b


Indirect Hash ptr (n-bits)
Hash addr (m-bits)
Search Data Storage
2^n
Search data RAM 662
Hash ptr RAM 660
2^m
Search Data (a-bits)
a-bits
654
n-bits

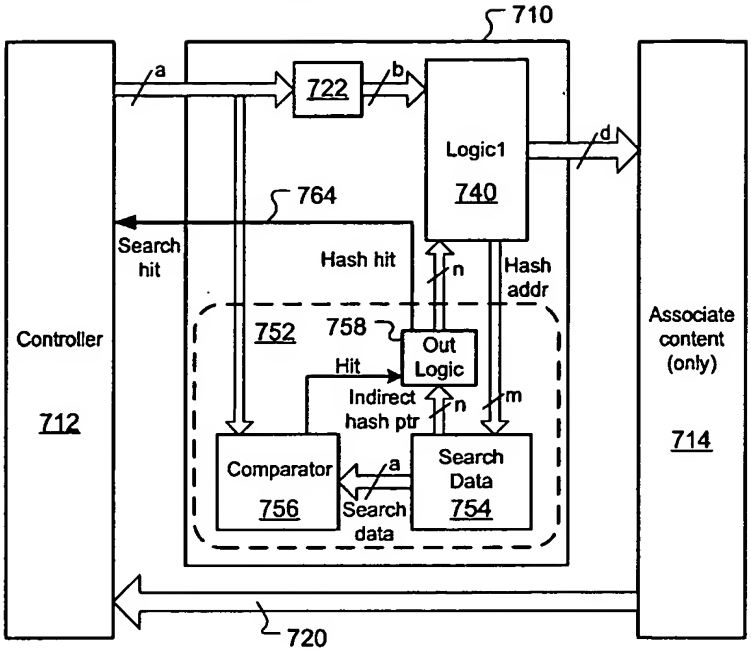

710
700
a
722
b
Logic1
740
d
764
Search hit
Hash hit
n
Hash addr
Controller
712
752
758
Out Logic
Hit
Indirect hash ptr
n
m
Comparator
756
a
Search data
Search Data
754
Associate content (only)
714
720

FIG. 10

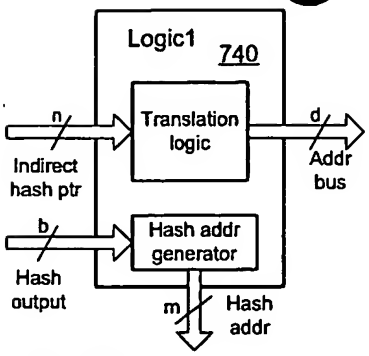
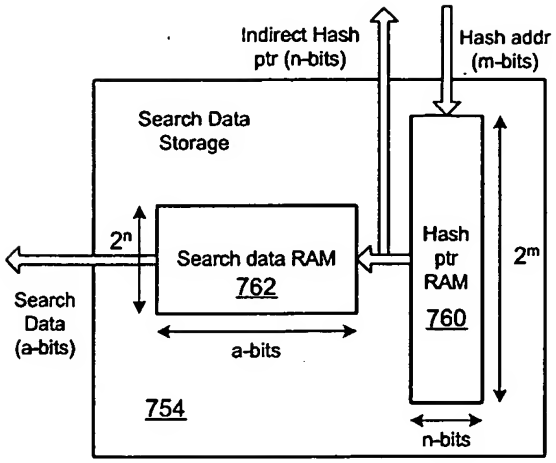

Logic1
740
Translation logic
n
Indirect hash ptr
d
Addr bus
b
Hash addr generator
Hash output
m
Hash addr

FIG. 11a

FIG. 11b


Indirect Hash ptr (n-bits)
Hash addr (m-bits)
Search Data Storage
2^n
Search data RAM
762
Hash ptr RAM
760
2^m
Search Data (a-bits)
a-bits
754
n-bits

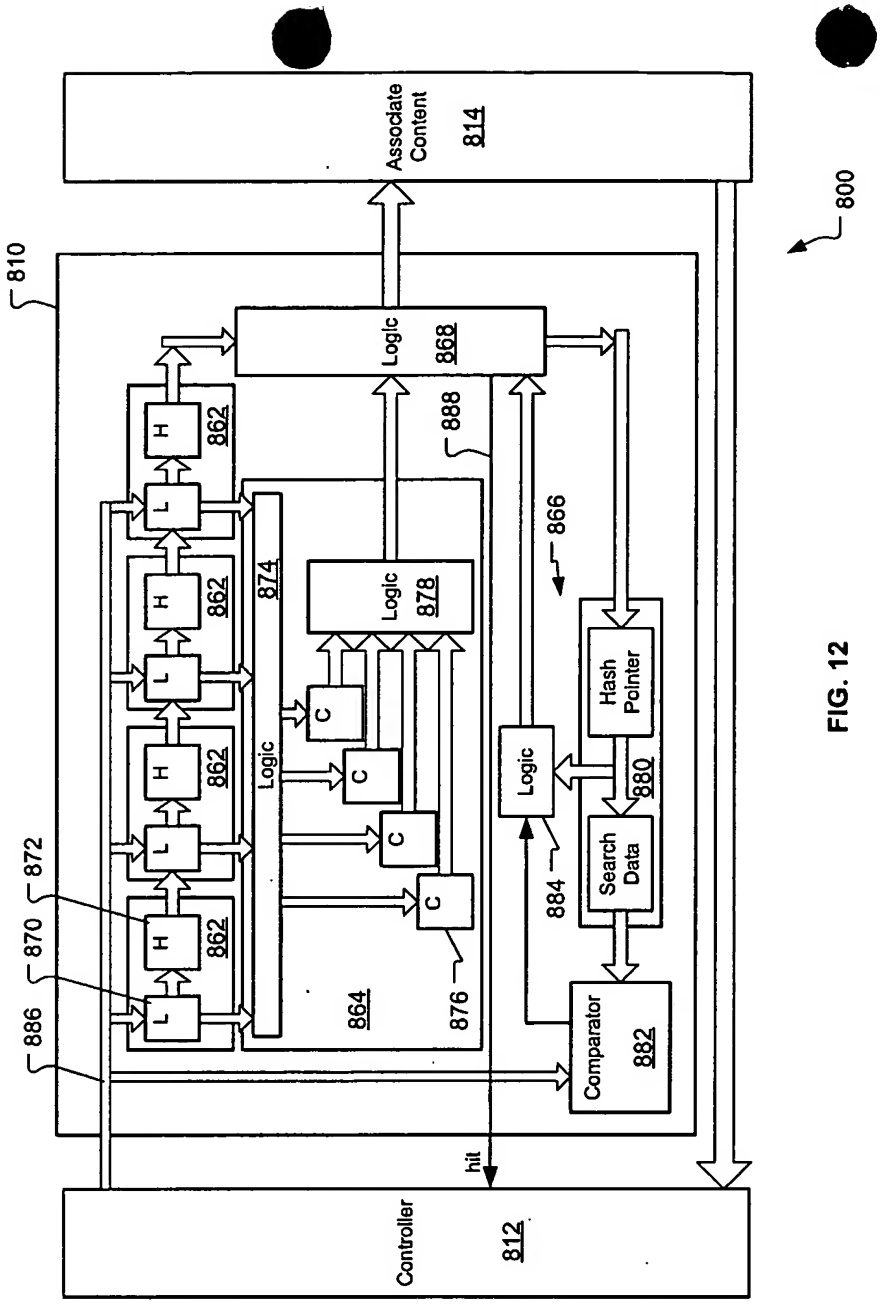

Associate Content
814
800
810
Logic
868
888
866
862
874
Logic
878
C
Logic
Hash Pointer
880
Search Data
884
872
870
886
864
876
Comparator
882
hit
Controller
812

FIG. 12

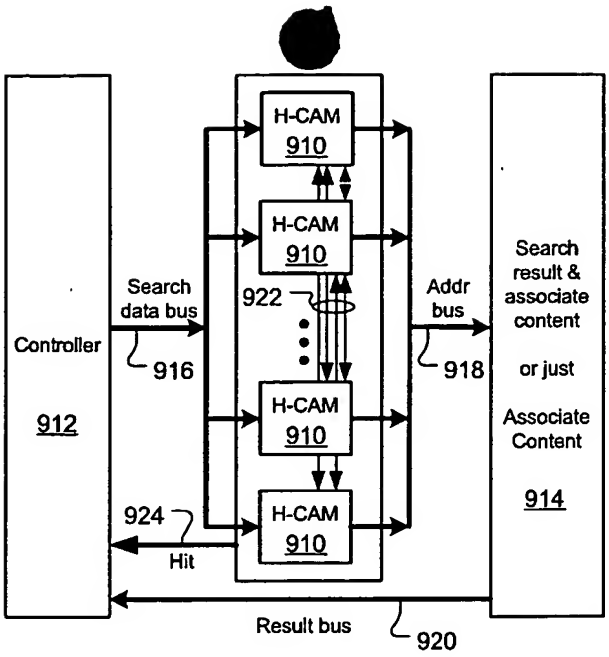

H-CAM
910
H-CAM
910
H-CAM
910
H-CAM
910
922
Controller
912
Search
data bus
916
Addr
bus
918
Search
result &
associate
content
or just
Associate
Content
914
924
Hit
Result bus
920
900

FIG. 13

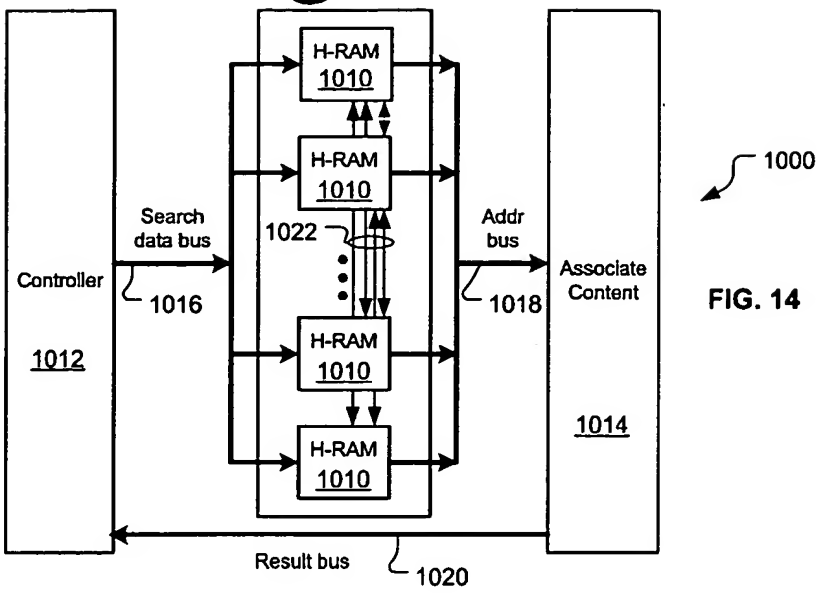

H-RAM
1010
H-RAM
1010
1022
H-RAM
1010
H-RAM
1010
Search
data bus
1016
Addr
bus
1018
Controller
1012
Associate
Content
1014
1000
Result bus
1020

FIG. 14

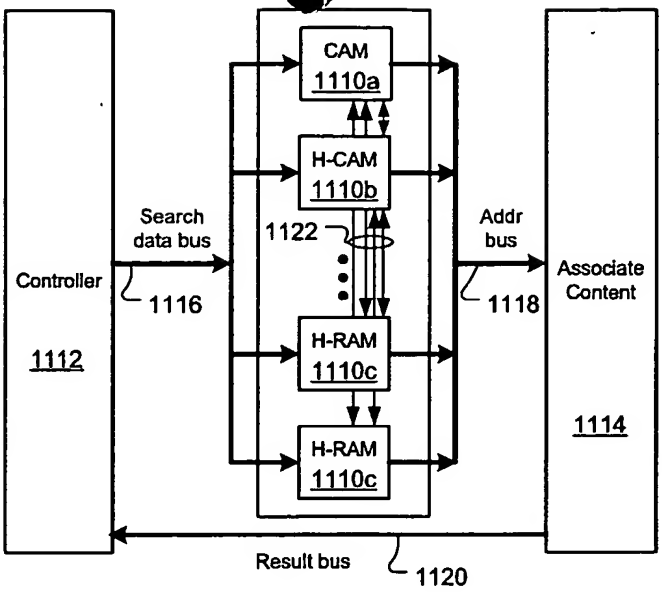

CAM
1110a
H-CAM
1110b
1122
H-RAM
1110c
H-RAM
1110c
Controller
1112
Search
data bus
1116
Addr
bus
1118
Associate
Content
1114
Result bus
1120
1100

FIG. 15